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(54) Back-lighting system for a transmissive electrooptic modulator using the light polarization effect

(57) The present invention relates to a back-lighting system for a transmissive electrooptic modulator using the light polarization effect.

The system comprises a means 21 for generating light rays, a reflector 20 for sending the rays back in a direction x and means 25 for guiding the light rays towards the electrooptic modulator, using a reflective linear polarizing film 23 positioned in front of the said means for guiding the light rays.

The invention applies to projection.

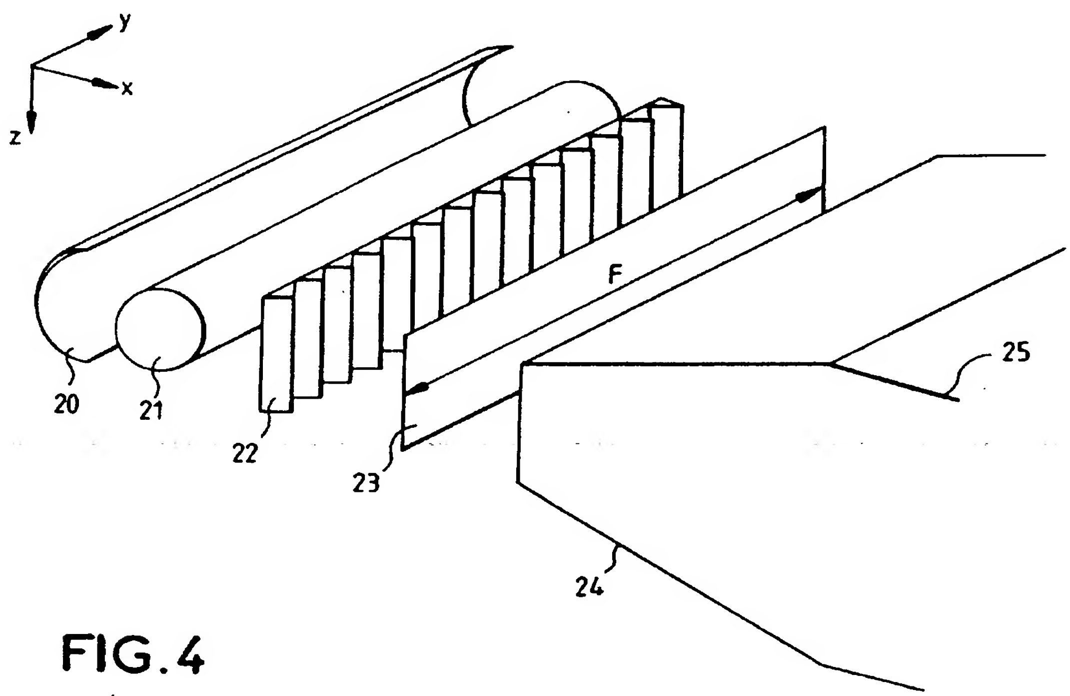

FIG.4

EP 0 907 050 A1

Description

[0001] The present invention relates to a back-lighting system for a transmissive electrooptic modulator using the light polarization effect.

[0002] Transmissive electrooptic modulators using the light polarization effect, such as, for example, liquid-crystal screens of the twisted nematic type, require for their operation a pair of polarizers which are positioned at the input and at the output of the modulator, respectively. When the transmissive electrooptic modulator is used in direct viewing mode, the polarizer 1 positioned at the input of the modulator is illuminated by unpolarized light 2, as shown diagrammatically in Figure 1. Since the polarizer only transmits correctly polarized light rays, an absorption of approximately 60% of the total light flux is observed. Moreover, when transmissive electrooptic modulators using the light polarization effect are used in direct viewing mode, a large variation is observed in the contrast and brightness characteristics, depending on the viewing angle.

[0003] In order to remedy these drawbacks, it has been proposed to illuminate the electrooptic modulator by collimated light. A system of this type is illustrated diagrammatically in Figure 2. In this figure, the reference 10 denotes the light source which may be produced by a cold-cathode fluorescent tube or a similar device. The reference 11 denotes a reflector sending the light rays back in the direction referenced x, the reference 12 denotes a light pipe or waveguide, the reference 13 denotes a microprismatic structure and the reference 14 denotes the viewing angle of the light rays at the output. Moreover, a collimation section 15 may be provided between the reflector and the input of the waveguide 12.

[0004] With this structure, as illustrated in Figure 3, the light emitted by the tube 10 is sent back by the reflector 11 in the direction x into the waveguide 12. In this case, the light rays reflected by the reflector 11 pass through the collimation section, producing a first collimation in the xy plane, and are then sent into the waveguide 12. In the guide, the rays emanating from the collimation region 15 are reflected by total reflection off the upper face opposite the microprismatic structure 13, towards this structure, and are then reflected by specular reflection off the said microprismatic structure 13 so as to leave the waveguide approximately perpendicularly through the upper face towards the electrooptic modulator (not illustrated). The path of the light rays is illustrated by the arrows I and I'. With this structure, the light flux is scattered mono-directionally at the output of the electrooptic modulator, thereby making it possible to improve the contrast characteristics.

[0005] The object of the present invention is specially, but not exclusively, to improve this type of structure so as to obtain a novel system having a high luminance gain.

[0006] The subject of the present invention is therefore a back-lighting system for a transmissive electrooptic modulator using the light polarization effect, comprising at least one means for generating light rays, at least one reflector for sending the light rays back in a first direction x and means for guiding the light rays towards the electrooptic modulator, characterized in that it includes a reflective linear polarizing film positioned in front of the said means for guiding the light rays.

[0007] Preferably, the orientation of the reflective linear polarizing film and the means for guiding the light rays are chosen so that the state of polarization of the light remains unchanged from the input to the output of the said means. This is because, from the laws of reflection, a polarization exists which is not disturbed too much by the multiple reflections inside the guiding means. Depending on the coordinate system chosen, if the output of the rays is along z, this preferred polarization is the polarization along y.

[0008] With this system, back-lighting is created such that the light rays have a linear polarization favourable to transmission through the polarizer. In addition, the rays emanating from the means for generating light rays or light source, as soon as they have this polarization, keep it throughout the propagation in the means for guiding the light rays towards the electrooptic modulator, the rays which do not have this state being recycled.

[0009] According to a preferred embodiment of the present invention, the reflective linear polarizing film, which constitutes a prepolarization and polarization return means, is a thin-layer film which transmits a linear polarization of given optic axis and which reflects all the others. Preferably, this film consists of the film sold by the company 3M under the trademark "DBEF".

[0010] According to another characteristic of the present invention, the means for guiding the light rays consist of a waveguide positioned at the output of the reflector so as to transport the light rays in the x direction, one of the faces of the waveguide, parallel to the x direction, having a microprismatic structure which specularly reflects the light rays and extracts them from the waveguide in a second direction, referenced z, perpendicular to the first direction.

[0011] Thus, inside the waveguide, the light propagates by total reflection off the upper plane surface of the waveguide and is extracted from the waveguide by reflection off the microprismatic structures. Since the reflections occur mostly in the plane, the linear polarization least affected during the propagation is therefore that along the y axis, i.e. the p polarization for the microprisms.

[0012] According to another characteristic of the present invention, the system includes a prismatic film which is oriented so as to be perpendicular to the means for generating light rays and is positioned between these generating

means and the reflective linear polarizing film. The function of this film is to increase the luminance at the centre. The film used in this case may be the film sold by 3M under the trademark "BEF" or similar films sold by Japanese companies.

[0013] Moreover, a half-wave retardation plate is positioned at the output of the means for guiding the light rays. This half-wave retardation plate makes it possible to preserve the linearity of the output polarization and ensures 45° azimuthal rotation towards the optic axis of the input polarizer.

[0014] Other characteristics and advantages of the present invention will appear on reading the detailed description given below of a preferred embodiment, this description being made with reference to the drawings appended hereto, in which:

- Figure 1 already described is a diagram explaining the operation of a polarizer on unpolarized light;
- Figures 2 and 3 are a perspective view and a cross-sectional view, respectively, of a back-lighting system according to the prior art;
- Figure 4 is a perspective view of a back-lighting system according to the present invention;
- Figure 5 is a diagrammatic top view showing the arrangement of a half-wave plate on the waveguide illustrated in Figure 4; and
- Figures 6A and 6B are conoscopes giving the luminance for the back-lighting systems of Figure 2 and Figure 4, respectively.

[0015] Figure 4 illustrates a perspective view of a back-lighting system according to a preferred embodiment of the present invention. In this figure, the reference 20 denotes a reflector of approximately cylindrical shape so as to surround a light tube 21 constituting the light source. In a known manner, this light tube 21 may be a cold-cathode fluorescent lamp or any equivalent system. The rays emitted by the light tube 21 are sent back by the reflector 20 in the x direction, shown symbolically by the orthogonal coordinate system x, y, z illustrated in the figure. According to one characteristic of the invention, a prismatic film 22 oriented perpendicular to the light tube 21 is provided after the tube on the path of the light rays. The function of this prismatic film is to increase the luminance at the centre of the system. By way of example, the film sold by 3M under the trademark "BEF" may be used as the prismatic film.

[0016] According to the main characteristic of the present invention, a reflective linear polarizing film 23 is positioned so as to be parallel to the prismatic film and after the said film on the path of the light rays. The reflective polarizing film 23 is oriented along the direction of the arrow F so that the rays emanating from the tube 21 having the polarization F pass through the film, the other rays being recycled. The rays which have passed through the film 23 are then sent into a means for guiding the light rays, consisting, as illustrated in Figure 4, of a collimation section 24 followed by an actual waveguide 25 of parallelepipedal cross-section in the embodiment shown in Figure 4. The waveguide 25 has, on its upper face, a microprismatic structure (not illustrated) so that the rays are reflected in the z direction given by the orthogonal coordinate system towards an electrooptic modulator (not illustrated). In the present description, a parallelepipedal waveguide is used, but it is obvious to those skilled in the art that waveguides having other shapes may be used, especially guides in which the surface having the microprisms is curved, as described in French Patent Application No. 97/06462 of 27 May 1997 in the name of the Applicant.

[0017] By way of example, a reflective linear polarizing film which can be used in the present invention and gives particularly useful results is the film sold by the company 3M under the trademark DBEF.

[0018] In order to show the advantages of the back-lighting system according to the present invention compared with a system of the type illustrated in Figure 2, a certain number of measurements have been carried out using a polarization analyser. The following parameters were compared:

- percentage of polarized light contained in the output beam;
- ellipticity of the polarization;
- azimuth with respect to Oy of the polarization.

[0019] The results obtained are given in Table 1 below.

Structure	% Polarized light	Ellipticity	Azimuth/Oy
Collimated (Fig. 2)	2 - 4%	4°	0° - 10°
Coll. + prepol. + pol. return (Fig. 4)	85 - 90°	0.4° - 4°	0° - 2°

[0020] The results given in the table therefore show that the desired polarization effect is indeed achieved since more than 85% of the output light is polarized. Moreover, the azimuth, which is very close to 0°, and the very low ellipticity show that, on the output side of the guide, the light is almost linear and well oriented.

[0021] In addition, in order to analyse the luminance gain obtained by the "polarization return" effect of the reflective linear polarizing film, a polarizer is cemented onto the output face of the waveguide with its transmission axis parallel to the polarization extracted from the guide. The results obtained in the case of a system of the prior art, such as that shown in Figure 2, and in the case of a system according to the present invention are illustrated by the conoscopes given in Figures 6A and 6B. The scale on the curves gives the minimum and maximum values, showing that, in the case of curve 6B, the maximum is much greater. Moreover, the central curve represents the 50% performance of the two systems.

[0022] The operation of the system according to the present invention is therefore as follows. The light is emitted by the tube 21 and then recentered by the crossed prismatic film 22. Approximately 42% of the light is transmitted in the form of linear polarization along Oy which enters the waveguide, while the rest is reflected towards the tube and the reflector in order to be recycled thereat. Light therefore returns through the linear polarizing film 23 and the prismatic film 22, and again 42% of the energy will be transmitted in the form of Oy-oriented linear polarization, and so on. Consequently, as illustrated in the conoscopes, an increase in the luminance is observed.

[0023] According to another characteristic of the present invention, a half-wave retardation plate 26, which preserves the linearity of the Oy-oriented output polarization and ensures 45° azimuthal rotation thereof towards the optic axis of the input polarizer, is laminated onto the output surface of the waveguide as illustrated in Figure 5.

[0024] This allows better adaptation to electrooptic modulators consisting generally of liquid-crystal screens whose brushing directions, namely the alignment of the terminal molecules, are oriented at 45° and 135° with respect to the Oy axis.

[0025] Thus, with the back-lighting system according to the present invention, a very wide viewing angle is observed with a good contrast level, and the vertical grey-level inversions are eliminated. Moreover, an increase of more than 40% in the luminance of the screen is observed, thereby giving a more agreeable image and the possibility of reducing the power of the light source, namely the electrical consumption. Likewise, it is also possible to increase the maximum contrast of the liquid-crystal screen by more than 20%, especially by using the half-wave retardation plate.

Claims

1. Back-lighting system for a transmissive electrooptic modulator using the light polarization effect, comprising at least one means (21) for generating light rays, at least one reflector (20) for sending the light rays back in a first direction x and means (25) for guiding the light rays towards the electrooptic modulator, characterized in that it includes a reflective linear polarizing film (23) positioned in front of the said means for guiding the light rays.

2. System according to Claim 1, characterized in that the orientation of the reflective linear polarizing film (23) and the means (24) for guiding the light rays are chosen so that the state of polarization of the light remains unchanged from the input to the output of the said means.

3. System according to Claim 1, characterized in that the reflective linear polarizing film (23) consists of the film sold by the company 3M under the trademark "DBEF".

4. System according to Claim 1, characterized in that the means for guiding the light rays consist of a waveguide (25) positioned at the output of the reflector so as to transport the light rays in the x direction, one of the faces of the waveguide, parallel to the x direction, having a microprismatic structure which specularly reflects the light rays and extracts them from the waveguide in a second direction, referenced z, perpendicular to the first direction.

5. System according to Claim 4, characterized in that a collimation means (24) lies between the reflective linear polarizing film and the means for guiding the light rays.

6. System according to any one of Claims 1 to 5, characterized in that it includes a prismatic film (22) which is oriented so as to be perpendicular to the means for generating light rays and is positioned between these generating means and the reflective linear polarizing film.

7. System according to any one of Claims 1 to 6, characterized in that a half-wave retardation plate (26) is positioned at the output of the means for guiding the light rays.

8. System according to any one of Claims 1 to 7, characterized in that the electrooptic modulator is a liquid-crystal screen.

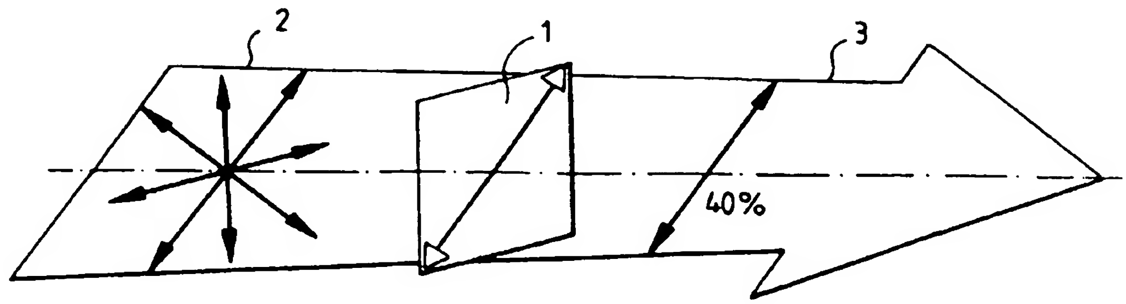

FIG.1

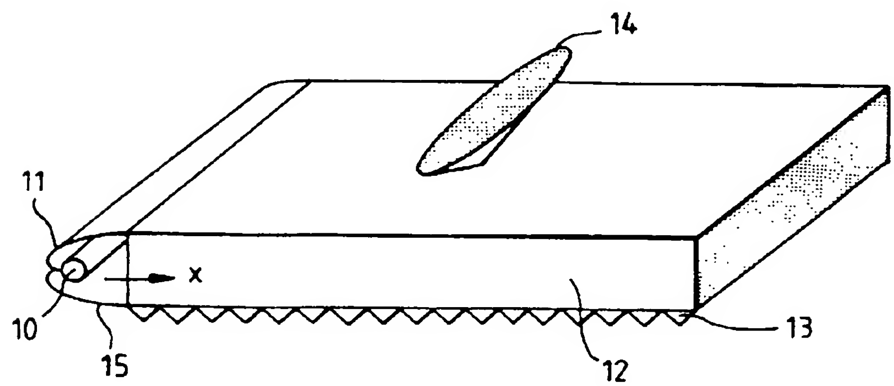

FIG.2

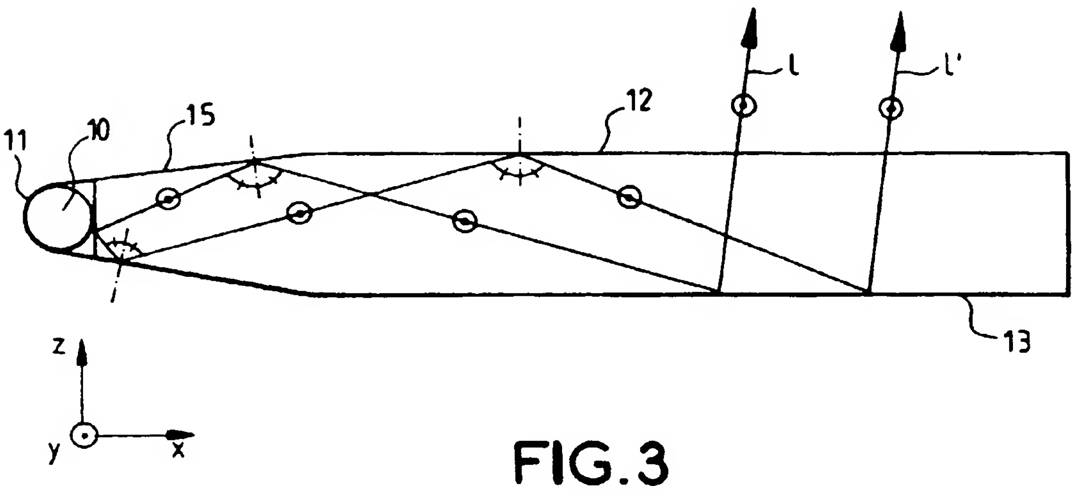

FIG.3

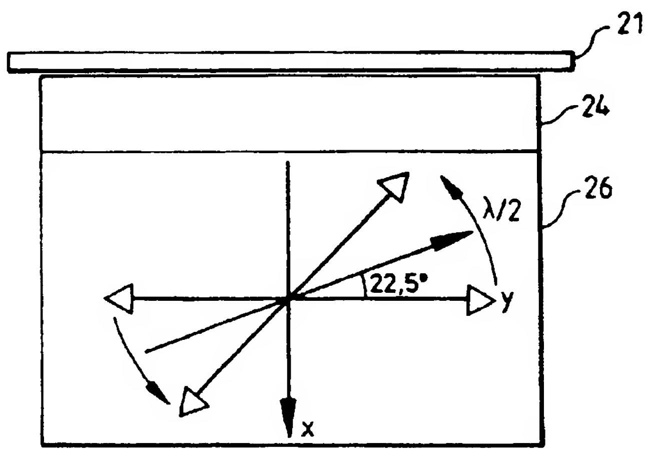

FIG. 5

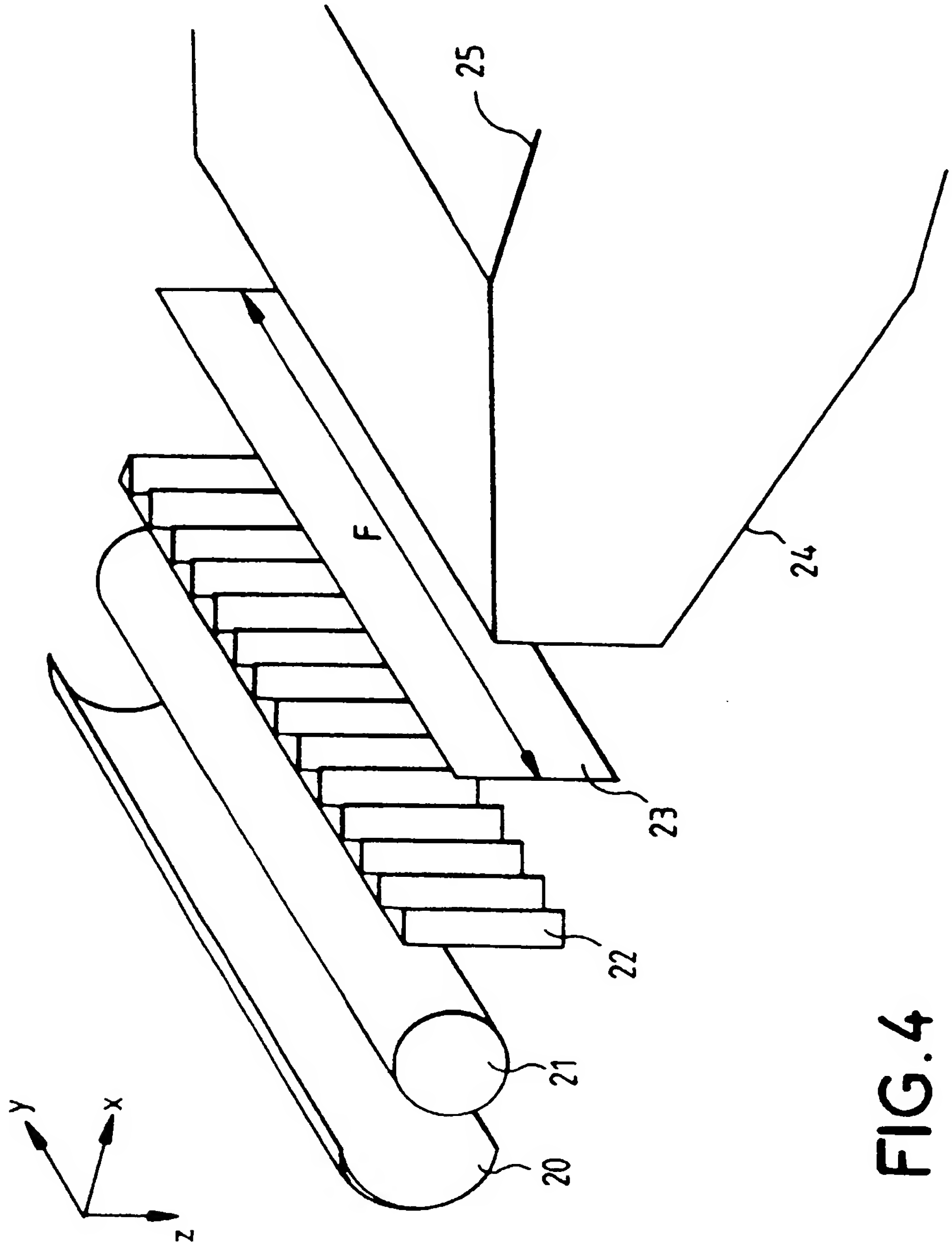

FIG. 4

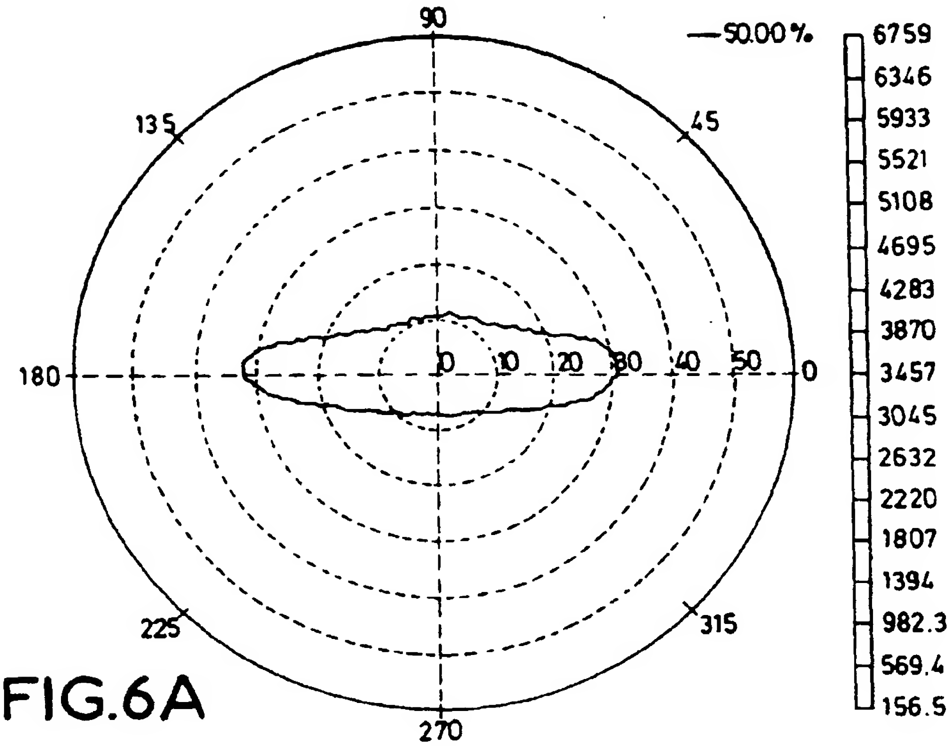
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FIG.6A

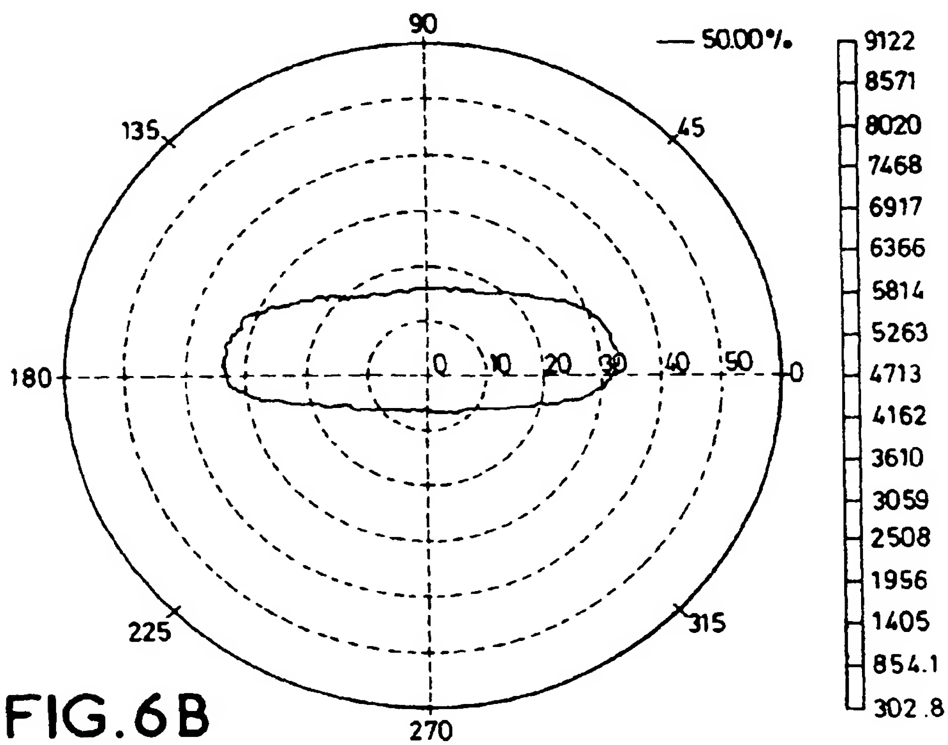
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FIG.6B

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EUROPEAN SEARCH REPORT

Application Number
EP 98 40 1881

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y	C.Y.TAI ET AL: "A 1.3:FLAT COLLIMATOR:A BACKLIGHT ASSEMBLY UTILIZING MICROPRISMS FOR HIGH ENERGY EFFICIENCY" SIDINTERNATIONAL SYMPOSIUM DIGEST OF APPLICATIONS PAPERS, vol. 25, 14 - 16 June 1994, pages 10-13, XP000492839 SAN JOSE (US) * abstract; figures 1,2 *	1,4-6,8	F21V8/00
A	PATENT ABSTRACTS OF JAPAN vol. 013, no. 269 (P-888), 21 June 1989 & JP 01 061724 A (NEC), 8 March 1989 * abstract *	1	
Y	WO 96 16292 A (K.LAITINEN) 30 May 1996 * abstract; figure 1 *	6	
Y	PATENT ABSTRACTS OF JAPAN vol. 016, no. 506 (P-1440), 20 October 1992 & JP 04 184429 A (SEIKO EPSON), 1 July 1992 * abstract *	1,4-6,8	TECHNICAL FIELDS SEARCHED (Int.Cl.6) F21V

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	29 September 1998	Malic, K

CATEGORY OF CITED DOCUMENTS

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